VACUUM CLEANING ENGINEERING

BY

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HAND BOOK

ON

VACUUM CLEANING PLANTS

—A—

TREATISE FOR THE USE OF ARCHITECTS

Drawing Specifications for Cleaning Plants

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DEDICATION

Realizing that little data has been placed before the public on the subject of **Vacuum Cleaning Devices**, the author has had prepared a small treatise on the subject, and in presenting it to the public with the hope it may prove of value, he dedicates it to the architectural profession of the Greater Northwest as being the one most vitally interested in the science and practice of air cleaning.

HAND BOOK ON VACUUM CLEANING

FOR COMPARING AND DRAWING SPECIFICATIONS.

As there are several classes of vacuum cleaning apparatus on the market it is advisable to describe the principles of operation and general construction of the various types and establish a standard rating in order to secure the desired capacity in the plant selected for given conditions and to reduce the required plant to a definite capacity rather than to take miscellaneous ratings.

Capacity—The Main Consideration in Selecting a Vacuum Cleaning Plant is to determine on **A Standard Capacity.** By this is meant the **Amount of Air to Be Drawn Through Each Renovator** (figured in cubic feet per minute), and also **The Vacuum to Be Maintained** to accomplish the desired results.

No two vacuum systems on the market use the same standard of capacity in making quotations, some makers bidding on equipment two to three times larger than others. **Even Though They Are Rated the Same Sweeper Capacity,** therefore the engineer should determine what in his opinion constitutes the proper standard of capacity and then select a plant or call for proposals on a plant of a **Specified Air Displacement and Vacuum.** This will compel all makers to bid on the same equipment and will assure the purchaser of getting exactly what he contemplates.

Before proceeding further, we will consider the principles of operation of a vacuum cleaning system and the various functions which are performed, and later discuss the various features.

Principle of Operation—The vacuum cleaning system consists primarily of an exhauster or vacuum-producing machine which is to create a partial vacuum in a piping system, thereby causing air to rush into the pipes to fill the void and in rushing into the pipes, carry the dirt along with it.

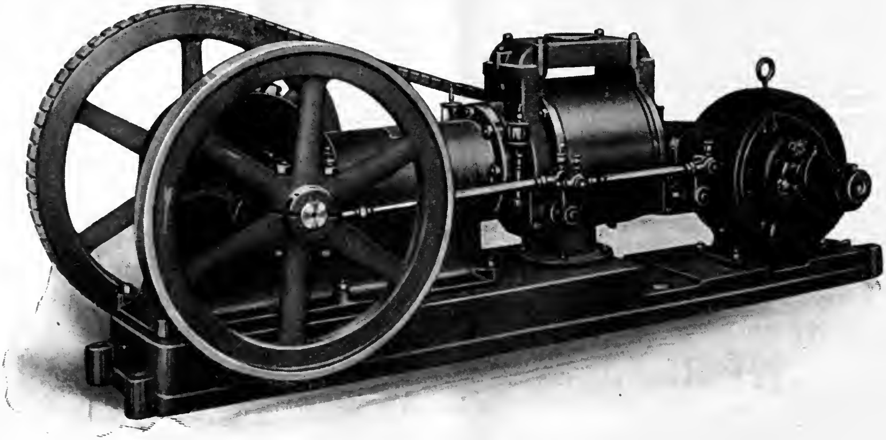
In a commercial unit, the building is piped with one or more vertical pipes, or "Risers," running from basement to top floor and connected together at the basement or lowest floor and carried to the location of the pumping plant. The cleaning appliances are connected to lengths of hose which are in turn connected to inlets, or valves, situated on each riser at each floor, the openings coming out at convenient points, usually in the baseboard. This piping system is not connected to the vacuum pump, however, as in that case all the dirt would enter the pump and cause damage, therefore the pipe line carrying the dirty air is carried direct to the dirt collector or "Separator," and after passing through this tank and becoming purified the air passes to the exhauster or vacuum producer and thence through the exhaust to a vent, either up a flue or to the outside of the building.

Operating handles are provided of suitable design to render the sweeping easy and convenient and the handles are usually provided with valves, permitting the air flow to be shut off as soon as the work is completed by one operator, thereby increasing the action at the other sweepers still in operation, decreasing power consumption.

A system of vacuum regulation is also required enabling the operator to maintain any desired vacuum required for his particular work.

COMPONENT PARTS—VARIOUS TYPES—VACUUM PRODUCERS.

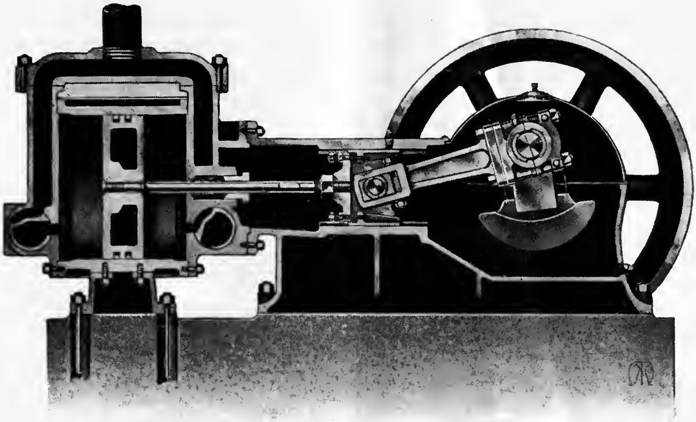
Double Acting Reciprocating Type—The Double Acting Reciprocating Vacuum Pump is the most efficient and also the most expensive to build. This type is built on the same lines as a standard air compressor, the piston being an airtight fit in the cylinder and provided



Horizontal Reciprocating Vacuum Pump Motor Driven.

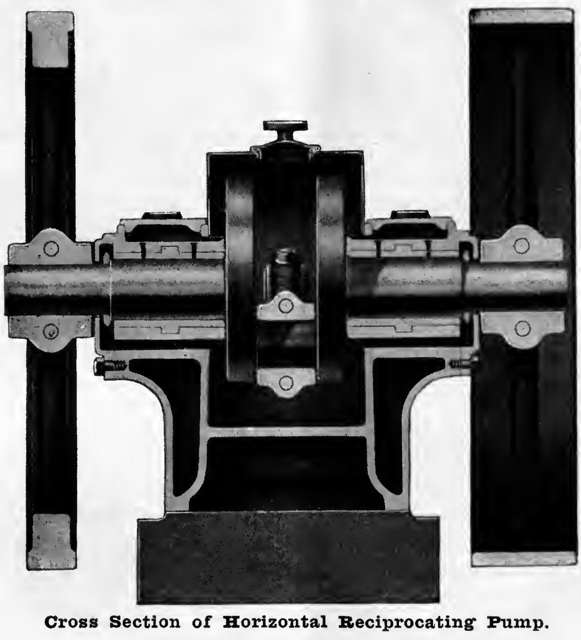
with rings to prevent leakage and take up all wear. The piston, in vacuum work, should travel very close to the cylinder head in order to force out all the air and eliminate an air cushion which would expand on the return stroke and cause loss in efficiency. The piston usually travels to within 1/16 inch of the heads and the valve chambers are made as small as possible, at the same time allowing large air ports for the passage of the air. The double acting type, as its name indicates, is a pump that performs work on both sides of the piston, that is, while the piston on one side is forcing out the air from the cylinder, it is drawing air into the cylinder on the other side and on the return stroke the operation is reversed.

A double acting pump has twice the capacity of a single acting pump of the same bore and stroke, and, as the piston friction remains the same in either case, the double acting type has an added efficiency over the single acting type exactly equal to the piston friction of one



Double Acting Reciprocating Pump Oscillating Valves (Cross Section).

cylinder and its valves, as the single acting type has the friction of two pistons and two sets of valves to give the same result.

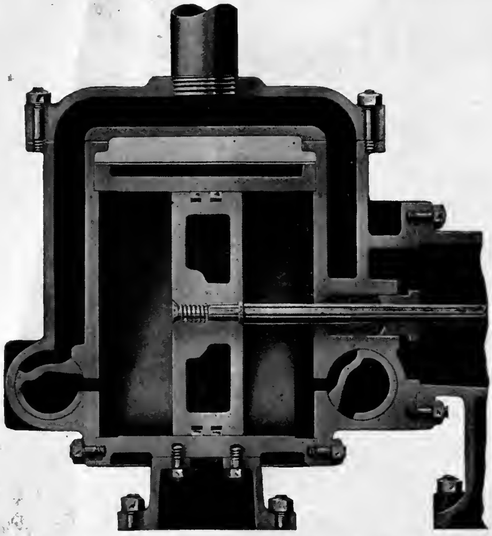


Cross Section of Horizontal Reciprocating Pump.

The double acting type has almost half the number of working parts and consequently has less inertia to overcome and takes up less floor space.

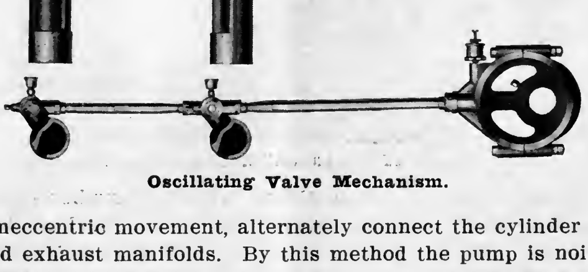
Single Acting Reciprocating Pump is the next in efficiency and is

of the same construction as the double acting pump except that it uses only one side of the piston and therefore has only half the capacity of a double acting type of the same cylinder dimensions.



Cross Section Double Acting Cylinder Showing Oscillating Valves.

Mechanically Operated Valves—The efficiency of the reciprocating pump may be increased by the use of mechanically operated intake and exhaust valves. These are usually of the oscillating type and utilize a cylindrical valve having large ports, which, as they oscillate



Oscillating Valve Mechanism.

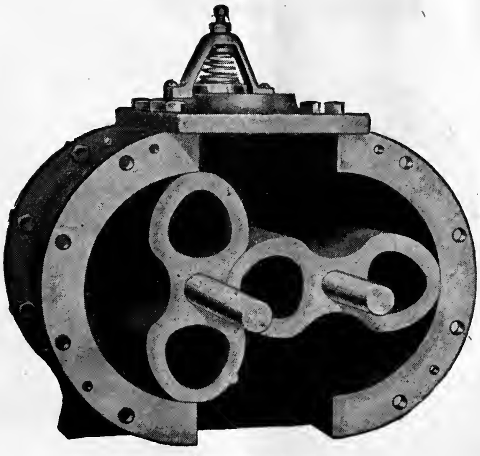
from a neccentric movement, alternately connect the cylinder with the inlet and exhaust manifolds. By this method the pump is noiseless in its operation and the internal compression necessary to force open

spring poppet valves is eliminated, permitting the pump to work at low temperature without a water jacket.

All piston pumps are of course provided with at least two and sometimes three sets of rings on the piston, the laps in the rings being spaced apart on the circumference of the piston so that the joints will not work together and cause leakage.

Single acting pumps are seldom used in present day construction as the cost of construction is about the same as double acting and they are not as efficient, compact or light as the double acting type.

Rotary Exhausters are built in several types. They are the cheapest type to build and are usually run at comparatively high speeds. The rotaries are most efficient on low vacuums (up to 10 inches of mercury), but above this point they have a tendency to leak, run hot and require an excess of oil, or are limited to short runs with stoppages for cooling.



Two Impeller Rotary.

Two Impeller Type Rotary is the type usually required when rotaries are called for, as their internal friction is much less. This type consists of an eliptical shell in which are two revolving members shaped something like a dumb-bell (see cut) which revolve towards each other, but without quite touching, leaving, however, only a minute space between impellers which is supposed to be taken up by a film of oil. The revolving of these impellers successively draws in the air and forces it out and, from its simplicity and fewness of parts, is the most desirable type of rotary. Its efficiency, however, is not particularly high and it is hardly practicable where high vacuum is required on account of the dead-air space that always exists in the cylinder.

Positive Displacement Rotary consists of a cylindrical shell in which is placed a cylinder or drum of smaller size which is eccentric to the main cylinder, that is, the circumference of the small drum will touch the inner side of the cylinder, leaving a crescent shaped space

Vane Type Rotary.

between the two. In the drum are several sliding vanes which are held out against the inside of the cylinder as the drum revolves, and these vanes force the air out of the crescent shaped space on one side and draw it in on the other side.

Turbine Type—This is merely a blower, consisiting of a large number of vanes on the impeller, or is a fan which is run at high speed and creates a suction of a **Large Volume of Air** but at a **Very Low Vacuum.** The turbines maintain under ordinary working conditions a vacuum of 1½ to 3 inches of mercury.

They are best adapted to bare floor sweeping, as the vacuum is not sufficient to remove tenacious material from a carpet, such as threads, fluff, hair combings, etc.

The fan type, on account of its low vacuum, requires about 300% larger pipe area for its use and the size of the hose has to be proportionately increased. A turbine usually employs a hose of 2-inch internal diameter for short runs and for long runs a section of 2½-

inch hose next the riser and reducing half way to 2-inch. The high vacuum systems require only 1¼-inch hose in any length up to 150 feet, providing they employ over 12 inches of vacuum, and the ease in handling a small, light hose is, of course, an advantage, and a saving in the maintenance cost. A turbine is practically identical in its operation to a planing mill exhauster for shavings in saw mills, with which everyone is doubtless familiar. The fan type is inapplicable for portable work as its vacuum is too low to allow washing or cleaning the air and all fine dust is blown back into the room.

Injector Type—A vacuum may be obtained by an injector system such as used for supplying feed water to a steam boiler and operated either by steam or compressed air. Injectors for vacuum cleaning are, however, very inefficient, and are not justifiable unless steam costs practically nothing.

The operation of an injector system under ordinary conditions costs at least three times that of a mechanically operated exhauster, and even at a low first cost, proves a very expensive device to operate.

This type of apparatus is now practically obsolete.

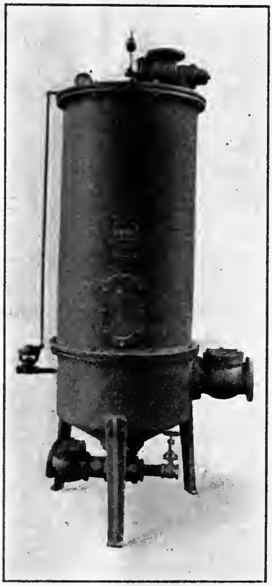
Separators.

A separator system to be of the greatest efficiency, should offer the least possible resistance to the air current—should effectively separate the dust and dirt from the air and deliver it pure to the pump; should have the least number of parts subject to wear and requiring attention or replacement and should be accessible on the interior by suitable hand-hole plates or covers and preferably a point in the tank where it can be entered if necessary. The most satisfactory type of separator is one embodying the above features and requiring little attention, the discharge of the dirt being automatic or semi-automatic in action.

Automatic Separators are of the wet separator type and are arranged to effectually mix the incoming dirty air with water, depositing all the dirt in the water and then by means of baffle plates removing the superfluous moisture from the air.

These automatic separators are designed to slowly fill with water while the vacuum is on until the water in the tank reaches a fixed level, at which point a float trips a valve and the pump is cut off from the separator, the vacuum on the system broken and the contents of tank is drained to sewer. When float reaches the low water level, the valve should be tripped back into the operating position and the performance repeated. The tank should discharge its water to sewer in about 20 seconds. A drain should also be taken from the bottom of tank to insure cleaning out, by flushing, any deposit which might collect in the bottom of the tank. There should also be means in the bottom of tank, where the air enters under water, for breaking the air current up into finely divided portions in order that all portions may come in contact with the water and be

thorougtly purified. There are **No Bags, Screens** or other obstructions in this type of apparatus, the water being the only purifying medium and, if the area of inlet pipe is sufficient, there will be no resistance from the water, as the air bubbles will rise of their own buoyancy.



Automatic Type Separator.

This is a most satisfactory type and is adaptable also for **Wet Scrubbing by Vacuum,** as the floors after being scrubbed can be run over with a vacuum squeegee brush and all the moisture drawn off the floor and down into the separator tank. In this process, however, the hose end should be placed in fresh water after the cleaning is complete and about ten gallons of clear water drawn down the hose and pipes to clear the dirty water and then allowed to draw air for a few minutes to dry. A solution of lye should be run through the pipes once a week, followed by clear water.

Spiral or Cyclone Type of Separators are of the same efficiency as the automatic, the only difference being that two tanks, each of the size of the automatic, are required, one being the dry-tank which receives about 90% of the dirt, and the wet tank which is operated on the same principle as the automatic except that it does not discharge automatically to sewer. The dry tank has an interior spiral partition whose cross sectional area increases as the air progresses and thereby slows the velocity of the air-current, at the same time carrying all particles in the air toward the bottom of the tank. The air flow be-

comes very sluggish near the center of the tank and the dirt settles of its own weight and the fresh air passes up through the central tube, thence to the wet separator where it enters under water and the remaining fine particles of dust are absorbed. The air then runs against spiral baffle plates until all the moisture has been deposited on these plates and the air goes to the pump clean and dry. This type has **No Bags or Screens** and there is **Nothing to Get Out of Order** or require renewal. The only attention being required is dumping the dry tank, which is accomplished by opening a suitable gasketed door in the base and allowing the dirt to fall out into a bucket or receptacle and flushing wet separator to sewer. These separators are always mounted on cast iron legs raising them about a foot or eighteen inches from the floor.

This type of separator is most satisfactory and efficient.

Bag Strainer.

Bag Strainers are used on many makes of machines and are almost invariably used on all makes in smaller sizes (usually from 1 to 3 sweeper sizes), and consist of a metal shell approximately 1½ feet in diameter by 4 feet high or equivalent, into the side of which the pipe line is brought and an elbow turned up, directing the air blast against a sheet metal dome or receptacle which deflects the air current down towards the bottom of the tank and at the same time, by the expansion

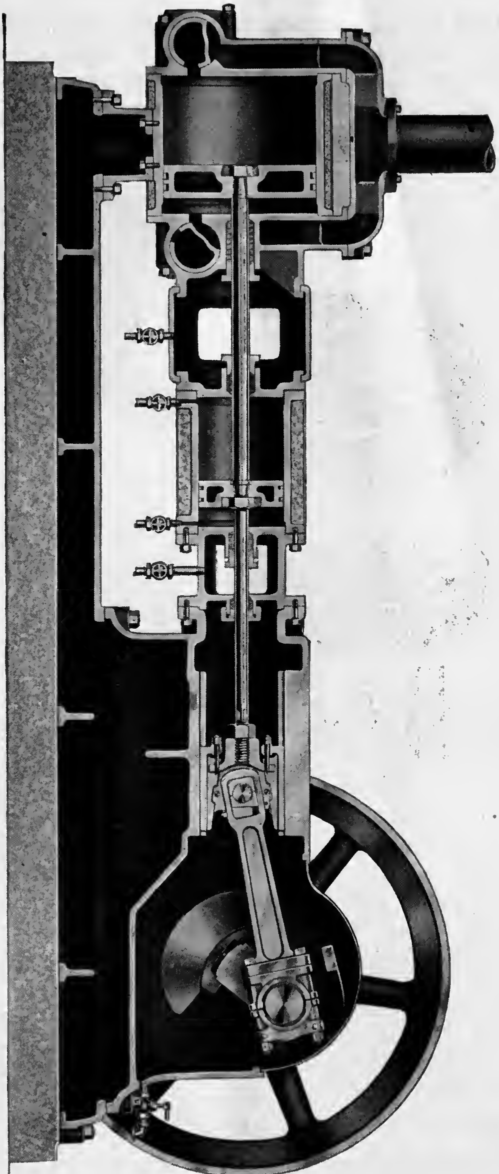
of the air in the tank, its velocity is decreased, therefore most of the dirt falls to the bottom, while the finer particles carry up with the air current which is passed through a canvas or cloth sack, which screens out the remaining dust particles. These sacks, of course, require frequent cleaning and beating, and hand-holes are arranged for that purpose. Also when sacks rot or become torn, the dirt carries over to the pump and chokes it, therefore it is customary to place an auxiliary strainer of some sort (one having a gauze or metal screen), between the bag-separator and the pump to prevent any dirt being carried over to the pump in case of damage to the sack.

The resistance of the sacks and particularly a deposit of dust over the sack tends to impair the vacuum and the efficiency unless the sack is cleaned at frequent intervals, and for this reason this type is hardly to be recommended in sizes larger than three sweeper, and not larger than two sweeper if the installation warrants first class equipment. The bag strainer is, of course, the cheapest type to build, and is generally used where first cost is the main consideration.

In some cases the bag strainer is used with a wet tank also, but this practice is being gradually discontinued, as a good bag strainer, even though not very efficient, should at least stop the dirt when used in conjunction with an auxiliary strainer.

Power Supply—Motors.

Electric motors are selected from the various standard makes to conform to the required current supply, and should preferably run at medium speeds, from 900 revolutions per minute (R. P. M.) to as high as 1,500 R. P. M. on small machines, however, the slower the speed the longer life and greater freedom from repairs and trouble in general. Motors should be required to carry full load indefinitely (under regular working conditions) without overheating.

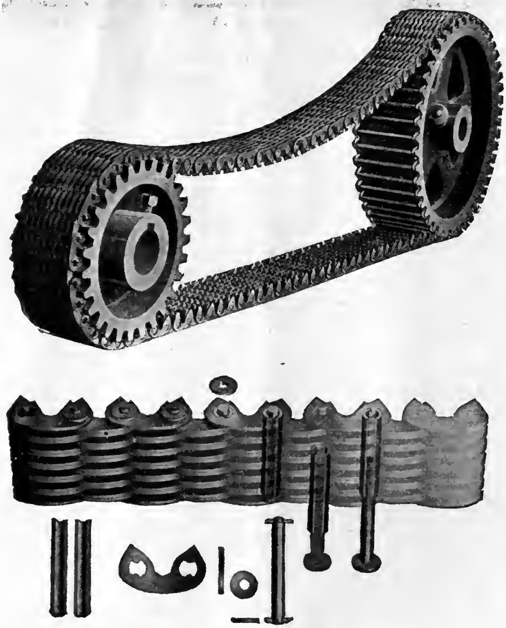


Steam Driven Reciprocating Double Acting Vacuum Pump. Mechanical Valves.

Drives.

The most efficient and satisfactory means of driving the pump from the motor is worthy of consideration as it has a decided effect upon the permanent service of the equipment.

Silent Chain Drive is the best known drive, and is made in several types. These silent chains ars positive in their action and quite similar to bicycle or automobile chains. They are noiseless in their action and last indefinitely with almost no wear, and transmit the power of the motor with the least possible loss.



Renold Silent Chain.

The Link Belt Company builds the Renold Silent Chain, a cut of which is shown, which illustrates the operation clearly, also the method of inserting new links or shortening the chain. The teeth mesh in special pulleys which are grooved to mesh perfectly with the pitch the chain will assume in an arc equal to the circumference of the pulley.

The Peerless V Chain consists of links similar to bicycle chain covered with a leather facing. These links have a V-shaped cross section and fit into V-shaped grooves in the rim of the pulleys and are wedged in as the load is increased.

Vacuum Regulators

are of two types, the vacuum breaker and the unloader types.

Vacuum Breaker is an inverted safety valve. It opens in towards the pump when the vacuum reaches a determined point and permits air being drawn in through its opening **Instead of the Pipe Line,** until the vacuum falls to the desired point. These breakers are of two

types, one type consisting of a differential piston valve which has an adjustment to open the pipe line to the atmosphere at any desired vacuum and a second adjustment to close the vent to atmosphere when the vacuum falls to the desired point.

The simplest form of breaker is merely a leather seated valve in the suction line which is held in its seat by a spring, with the vacuum tending to pull it open against the tension of the spring. By varying the tension of the spring the valve can be made to pull open and admit air when the vacuum on the suction line reaches any desired point.

Vacuum Unloader operates to best advantage on pumps having poppet discharge valves and performs its function by cutting off the suction line of the vacuum pump at a point near the pump so that it cannot draw air after the vacuum has reached a determined value. As there will be no air drawn into the cylinder, there will be no air to force out through the exhaust, therefore the discharge valves will not open and the pump will operate in a vacuum and no work will be performed in the cylinder.

Where mechanical valves are used on the pumps, the breaker is to be preferred, but where poppet valves are used on exhaust, the unloader is the most efficient.

Hose—The vacuum hose should be of a type which will prevent collapsing under any vacuum which the machine is capable of producing, and should have an inner lining so constructed that even though the vacuum runs up to a high point, the lining will not pull loose and tend to close up the pipe. This is one of the most common difficulties in vacuum hose. The hose should be reinforced with wire and at the same time the inner bore of the hose should be smooth, and it is preferable to have the outside surface smooth also.

The nipples of the hose connections at each end should have reamed ends on a gradual taper so that at the end of the nipple there shall be no shoulder to catch the incoming dirt. Hose connections should be of standard hose thread.

Metal Hose constructed of steel ribbon wound spirally with locked joints packed with rubber, forms the lightest and most flexible hose known.

This hose can be had either bare or with a cloth covering, the latter being a trifle more expensive. The bare steel hose being almost smooth on the exterior and smoothly finished, is not inclined to mar furniture even though uncovered, and appears a satisfactory hose to use. The absence of the cloth covering increases its flexibility considerably. The surface of the hose is galvanized and it can therefore also handle water with impunity.

Metal hose, if not dented or sprung, and handled with ordinary care, has a long life. The force required to pull steel hose around

right angle bends is only about one-fourth that required for rubber hose.

Rubber Hose is most commonly used and is generally in the 1 or 1¼-inch internal diameter size, which is suitable for all systems employing 10 inches of vacuum or over. Larger hose is unwieldy to handle and is generally unsatisfactory on account of the hardship it imposes on the operators. Rubber hose is also adaptible for wet-scrubbing, and will handle water as well as air. Rubber hose should last about three years with careful handling.

Inlets or Hose Connections are of many types. The most substantial and dependable is a standard screw hose connection. A small, neat design of male thread for hose connection is provided and a gasketed cap (secured by chain) provided to close the opening when not in use. These connections are **Always Tight** and in general show greater efficiency than the automatic types which are held shut by vacuum. Hose connections should have flanges and should not project from the finish more than approximately 2 inches. The finish should be polished nickel or made to harmonize with the surrounding hardware.

Flush Valves are used where it is desired to make a finished job and conceal the hose connection. These are made with a neat metal surface, usually circular in shape and arranged to fasten with a simple lock. For use, the cover is lifted up and the hose inserted. When the opening is closed, a pad of rubber attached to the cover is drawn against the seat and the vacuum draws it tight enough to close the opening.

Requirements to Be Demanded.

1. The machine should clean rapidly and thoroughly.
2. The machine should preferably be capable of taking up scrub water.
3. The machine should run quietly without vibration.
4. The machine should run at low speed if long wear is desired.
5. The machine should be accessible for adjustments and all parts should be renewable and interchangeable.

(1) For rapid cleaning, it has been demonstrated by long experience that in commercial work, such as cleaning buildings, or wherever help is paid for the purpose of cleaning, a vacuum of at least 10 to 12 inches should be maintained at the separator, and the displacement of the pump should provide for at least 75 cubic feet of air per minute for each sweeper in use. Thus, if one wanted a plant to permit three janitors to clean simultaneously (known as a three sweeper plant), an air displacement of 3 times 75, or 225 cubic feet of free air should be required of the pump with a guaranteed vacuum of 10 to 12 inches of mercury. This will clean practically anything which does not have to be literally scraped off the floor. Where long

horizontal pipe runs are used, 80 to 85 cubic feet displacement per sweeper is preferable.

The vacuum desired should be specified at the pump or at the separator, for this is always constant and with given conditions to start with and proper piping system, the results will always be uniform at the renovator. The test for vacuum should be made with the required number of sweepers connected to 50 or 75 foot lengths of hose in actual operation and the openings through renovators should be equal to one square inch in area, except for special work.

In preparing specifications, it is best to disregard the number of sweepers in the specifications themselves and call for air displacement in cubic feet—found by multiplying 75 to 80 by the number of sweepers to operate simultaneously. The vacuum should also be specified at not less than 10 inches of mercury and in this manner, all types of machines will bid on the same identical capacity instead of using their own ratings, which vary greatly.

(2) At least 3 h. p. should be required for each sweeper, as this power is actually required to achieve the above results.

(3) The machine should be quiet in operation and not disturb those in adjoining rooms. The parts should be balanced and should operate without vibration. In reciprocating machines it is preferable to use mechanical valves, which reduce noise and increase efficiency

Chain drives should be specified for quiet operation and efficiency, and chain guards should be required to prevent clothing being caught and the throwing of oil.

(4) The pump should run at low speed, as the life of the pump is dependent upon the speed at which it operates.

The piston speed of pumps should vary between 150 and 300 feet per minute for ordinary work, except in residential plants, which may run up as high as 500 feet per minute.

For commercial plants, the revolutions per minute in pumps designed for long life should not exceed 250 revolutions per minute. This allows a pump to carry its load with ease, with little vibration, and eliminates loss in efficiency at the ends of strokes to some extent.

The machine should not overheat from long runs at full capacity, and should be able to operate for eight hours without stop, if desired, without showing distress. The temperature of the pump should keep within safe limits and none of the sliding or moving parts should assume a temperature above 100 degrees higher than the surrounding atmosphere.

(5) All parts of the machine should be adjustable. The engineer or operator should be able to take up wear on any moving part by means provided in the machine for this purpose, and in a convenient manner.

All parts of the machine should be interchangeable and removable,

so that in case of a breakage or accident, a new part may be ordered from the manufacturer and fit into place as the original did.

Means should be provided for take-up of the chain or belt drive in a simple and convenient manner.

SUMMARY OF DIFFERENT TYPES OF DEVICES.

(Method of making efficiency tests follows this list.)

The various components are tabulated below in the order of their approximate efficiencies and comparative longevity.

	Efficiency.	Length of Life. (Comparative Val.)
Pumps—		
Reciprocating, double acting, with mechanical valves	95%	100%
Reciprocating, double acting, poppet valves	87%	100%
Reciprocating, single acting, mechanical valves	80%	100%
Reciprocating, single acting, poppet valves	75%	100%
Rotary—		
Two impellor type, when new	70%	45%
Rotary sliding vane type, when new	62%	35%
Turbine—		
Multi-vane or fan (4-inch vacuum)	35%	60%—100%
Injector, Steam or Air—		
Steam from local boiler	30%	100%
Compressed air from separate compressor	24%	100%
Motors—		
All standard makes of motors have the same characteristics, and little is to be said on this point, except that medium speed motors should be used and speeds should be kept under 1,500 revolutions per minute in general, and preference given to slow speed motors.		
Electrical efficiency of average motors in sizes used for vacuum cleaning work	84%	100%
Drives—		
Chain drives, of Peerless V, Renold Silent Chain, Morse and similar types	98%	100%
Geared, with rawhide pinion	90%	90%
(But is noisier than silent chain.)		
Leather belt	75%—85%	50%

	Efficiency.	Length of Life. (Comparative Val.)
Separators—		
Automatic or Spiral or Cyclone types (using no bags or screens)	100%	100%
Bag type, using canvas sack or gauze screen for filtering the air	98%	90%
Note.—When sacks are not cleaned regularly the efficiency drops gradually. When sacks are dirty, average	70%	
Regulators of Vacuum—		
Vacuum unloader (used with poppet valves)	75%	100%
Vacuum breaker, regulating type	70%	100%
Hose—		
Rubber, wire-reinforced, smooth bore	75%	50%
Steel, flexible, rubber packed	70%	100%
Note.—The rubber hose is a trifle more efficient, owing to its smooth bore, but the flexible steel hose will wear longer, and the actual working results are almost identical, and the steel, being half the weight and twice the flexibility of the rubber, make it the more easily handled. The steel hose is preferable in the uncovered state, leaving the bare metal exposed. The ends, however, should be reinforced, to prevent cracking at the operator's handle or at wall connection.		
Wall Valves for Hose Connection—		
Standard 1-inch hose fiitting, with gasketed cap	100%	100%
Automatic flap or self-closing valves	75%	50%

A standard hose thread with a cap and rubber or leather gasket affords an absolutely air tight connection when hose is not connected thereto, and will last indefinitely.

Automatic flap valves which the vacuum draws shut, frequently wear out of alignment and particles find lodgement under the seat, causing leakage. This type is not as desirable unless finish requires a flush type.

VACUUM SCRUBBING.

(See Appendix.)

General Tests.

The pump effiiciencies of positive displacement types in the fore-

going list are determined by accurate test, made in the following manner:

Pump Efficiency Test—The various pumps to be tested are connected in turn to an air-meter (of Queen Co. or equal manufacture) and hose or pipe connection is made to the inlet side of the meter which is regulated as to size of its opening until the vacuum gauge stands at 10 inches of mercury. Under these conditions, with the pump maintaining constantly 10 inches vacuum, make a five-minute run and take readings on the air meter to determine just how many feet of air pass the meter per minute, at the **Same Time,** have an assistant take the current consumption reading on the motor and at the end of the test an accurate record will be made of the exact current consumption to pass a given quantity of air at a 10-inch vacuum.

If several machines are tested, the different results can be resolved down to the current consumption per foot or per ten feet displacement and the various pumps then compared and the relative efficiences shown. If the tests are correctly made, the results will approximate those shown in the above table of pump-efficiencies.

Testing Plant Operation—The first consideration is proper cleaning, and if the plant does not properly care for this part of the work, the further tests of the apparatus are inconsequential.

A good test is to take a piece of carpet having a good nap, and fill it with small particles of cotton batting, embroidery silk fluffed out, also threads, feather tips and similar tenacious material, also a quantity of plaster of paris,and the whole tramped into the carpet. The carpet-renovator should then be applied and should remove this material in a thorough manner. If the plant will remove this class of material, the cleaning may be deemed satisfactory.

Test for Separator System—The U. S. Government call for the machine to clean a mixture of fine sand, powdered charcoal and white flour, approximating at least two quarts scattered over a large area and cleaned from various outlets without allowing any of this mixture to reach the pump. This test is, however, usually waived and the guarantee on the effectiveness of separator held in its stead.

The plant should run smoothly without noise or vibration, and should not show any movement at point between pump base and foundation.

There should be no lost motion in any of the moving parts and the plant at the end of an hour's run under full capacity should not be warmer at any of its moving parts than a temperature which can be borne by the hand.

Oil Consumption—As soon as the machine has had an opportunity to wear to a working fit, it should be capable of operating with an oil consumption of not to exceed 20 drops of oil per minute to any one moving part.

PIPING SPECIFICATIONS.

Standard black iron pipe or electrical conduit may be used for vacuum piping and all pipe ends must be reamed to the full diameter of the pipe and the ends squared true. All rough particles, finns, or burrs must be removed from pipe ends. The threads should be run a little further than ordinary pipe work to allow the pipe end to set securely and squarely against the shoulder of the recessed fittings, which are to be used throughout. The red-lead or joint compound is to be put on the pipe and **Not Into the Fitting.**

The fittings used on the entire vacuum piping are to be of the recessed, drainage type **With Long Radius Bends,** usually known as **"Durham"** fittings.

Long sweep tees are to be used on all risers at each floor at a level determined by the architect, and these tees are to be bushed to one inch and a one-inch nipple put into same of sufficient length to project three-quarters of an inch beyong the finish.

(NOTE—If the construction is such at any particular point that a flush type outlet is required, then specifications should state that at such point the tee is to be provided with the particular fittings necessary to the proper installation of the flush outlet funrished by owner.)

At the point where risers project through into basement (or lowest basement), a flanged union with gasket is to be placed close to ceiling, and below the union, with a nipple should come a long sweep tee, the sweep of the tee being in the natural direction of air flow and the unused horizontal end of the tee plugged for a cleanout.

On all horizontal runs of over thirty feet, flange unions must be placed at thirty-foot intervals and in all flange unions the pipe ends must be square and project through flush with the face of the flanges.

(NOTE—With this construction, all portions of the pipe line are accessible for cleaning in case of a stoppage. The flange union at base of each riser allows the pipe line to be broken at that point and the entire riser cleaned, working from floor to floor, and the plugged end of tee on the horizontal allows horizontal to be cleaned, and if the horizontal is long the breaks of thirty feet will render the work easy and will not require the services of any skilled help.)

All piping should be brought to within ten feet of the proposed location of the vacuum plant and all horizontal pipes, if more than one, should be brought together into one pipe of ample capacity, and at least as large as the inlet pipe connection for the vacuum pump. The method of bringing the various horizontals together shall be by means of standard Durham fittings with flange unions, enabling the horizontals to be opened at the ends, or, if only two horizontals come together, a double long sweep tee may be used with the unused opening plugged for cleanout.

The entire piping system shall be so installed that every foot of the piping system shall be available for cleaning in case of a stoppage.

In walls or concealed places where it is necessary to make bends in the pipe, same shall be done by **Bending** the pipe in every instance possible and **not** with the use of fittings.

In cases where it is necessary to lay vacuum pipes in cement

floors or horizontal runs in walls, cleanouts should be provided at least every forty feet, and closer if possible, either by means of a small hand-hole plate giving access to a plugged cleanout, or the cleanout may be brought flush with the surface and covered with a flush deck-plate or similar cover.

Exhaust Piping requires only standard fittings, as these pipes will contain no dirt. The exhaust pipe should be vented into the boiler stack or in fact any good flue, and if such flue has a boiler, furnace of other heater vented into it, the air exhaust should be **Brought in Above the Dampers** and an ell placed on end of discharge pipe, directing the blast up the flue. If building has no flue, use muffler and oil separator and vent in most inconspicuous place or under sidewalk—see architect.

Sizes of Vacuum Pipes—Nothing less than 2-inch pipe should be used for any size of plant. The proper method of calculating pipe sizes is to figure the exact pipe resistance and allow for a drop of not over 2 inches on the piping system. The following will be found adequate for general use, for buildings not over 12 stories:

For one-sweeper plants, 2-inch piping, both risers and horizontals.

Two-sweeper plants, 2-inch risers, 2-inch horizontals.

Three-sweeper plants, with two or more risers, use 2-inch pipe for risers. If only one riser, use 2½ -inch pipe for riser, and in either case 2½-inch pipe for horizontals.

Four-sweeper plants, 2½-inch risers (if only one, use 3-inch), horizontal, 3-inch.

Five and six-sweeper plants, 2½-inch risers (if only one riser, 3-inch); horizontals, 3-inch.

Seven to ten-sweeper plants, 3-inch risers (if only one, 3½-inch; horizontal, 4-inch.

The piping sizes, of course, depend entirely on the number of openings that will be in use on each riser simultaneously, and as the janitors work promiscuously from one point to another, it is well to estimate plenty of capacity to provide for cases where a number of janitors are all using the same riser at one time.

The above sizes have been found sufficient for all ordinary cases.

Any pipes exposed to dampness must be galvanized.

Water Connections (all galvanized)—A three-quarter water connection is to be brought to within ten feet of the location of the machine. (Assuming a type of plant or separating system is called for which requires water. This water connection shall be controlled by valve at branch of main pipe.

Sewer Connection shall be provided (if automatic separator specified, 4-inch; if regular wet separator system, 3-inch; bag type, none required.) Sewer connection to be provided by owner and connected to by contractor installing vacuum plant.

FOUNDATIONS.

The vacuum pump and all appliances having moving parts should be supported on proper foundations.

If the machines operate without vibration and are of medium power, a substantial cement basement floor is ample, providing the construction of the sub-base of the machinery is such that it will keep the moving parts well clear of the floor and out of water which might accumulate on the floor.

It is preferable, however, to build a regular foundation of cement at least six inches above the floor on plants using over 10 horsepower, and if the cement basement is already in, it should be picked into to roughen the surface sufficient for the foundation to hold and the foundation bolts should go entirely through the foundation in any case.

In setting foundation bolts in a foundation, a short length of pipe should be placed around each foundation bolt (the bolts having large washers at their lower ends) and the end of pipes brought flush with the upper surface of the foundation. The pipes should be about three times the diameter of the bolts and the space between bolt and pipe should not be filled until after the machine is in place. This construction allows the bolts to be moved in any position to accurately fit the holes on foundation, and after the machine is set the space between bolts and pipes is filled in with soft cement and allowed to harden.

A template of the foundation should always be made when the foundation is laid out and holes bored corresponding to the holes in sub-base. This template is then laid over the bolts after they are in position and holds them in place while the cement sets.

For fine work, a grouting is run between foundation and sub-base after the machine has been perfectly leveled.

WIRING.

The wiring should be considered in advance, and if the architect desires this work included in the general electrical contract (which is usually the cheaper method) it should be stated in the electrical specifications that motor circuit should be brought to within ten feet of the proposed location of the vacuum plant, and his work should include the proper fuses and switch at the point from which he brings these mains.

The architect, by figuring 3 1-3 horsepower for each sweeper he contemplates using, can state the size motor to be wired for.

The vacuum contractor should then be required to make all connections from the point within ten feet of his machine, furnish necessary operating switch and fuses in proper cabinet and the rheostat or starting device for his motor and finish the work in a workmanlike manner in accordance with local rulings.

CONSIDERATIONS IN DRAWING SPECIFICATIONS.

Regardless of what kind of equipment is to be installed, the capacity should be standard; that is, the capacity of the vacuum pump, regardless of its type, should equal at least 75 cubic feet of air displacement to each sweeper, the vacuum should preferably be set at 10 inches of mercury under regular operating conditions, and the horsepower at not less than 3 horsepower for each sweeper. Then the various types may be allowed to figure their respective types of apparatus, providing they give the standard required for good cleaning. If the building justifies the installation of a high grade plant, then it would be advisable to specify the double acting reciprocating type, with mechanical valves, and use the various items of equipment as specified heretofore, selecting the types of the highest efficiencies, as shown in the preceding table. Briefly, specifying Double Acting Reciprocating Pump, Chain Drive, Automatic or Spiral Type Separators, and requiring slow speed machines. A list of specifications should be attached pertaining to the construction of parts, which each bidder should answer. (See specifications.)

COMPARATIVE COSTS OF MACHINES.

A good reciprocating type plant with necessary appliances should cost in the vicinity of $450.00 per sweeper capacity, **Not Installed.**

A rotary plant should cost about $350.00 per sweeper capacity, both being based on the same capacity, **Not Installed.**

These figures are, of course, only approximate, and will depend largely on the locations and distances from the factories supplying the equipment.

TYPICAL SPECIFICATIONS

In presenting specifications, bidders should understand that the requirements called for are binding and that substitutes will not be considered.

SPECIFICATION FORM; Specifications covering a **Vacuum Cleaning Plant,** for .... (Name of Bldg.)........ located at ....
....

Sealed bids will be received by ...., at........(Address)........until........(date)........, for a vacuum cleaning plant capable of operating ...... (Number) ...... sweepers simultaneously, as further described in detail. A copy of these specifications is to be signed and submitted with each bid and will constitute a part thereof.

DELIVERY—Bidders will state what delivery they are prepared to make (Or specified delivery shall be called for).

CAPACITY—The plant shall consist of one unit having a capacity of

One sweeper residential, 60 cubic feet free air displacement.
One sweeper commericial, 75 cubic feet free air displacement.
Two sweeper commericial, 150 cubic feet free air displacement.
Three sweeper commericial, 225 cubic feet free air displacement.
Larger plants based on number of sweepers multiplied by 75 and shall maintain a working vacuum of (Residential 8 inches) not less than 10 inches of mercury.

EXHAUSTER—The exhauster or vacuum producer shall be (If high grade equipment is required) of the reciprocating, double acting type and preference will be given to mechanically operated valves.

The speed of exhauster (if larger than 1 sweeper) must not exceed 250 revolutions per minute and must deliver the specified displacement and vacuum without exceeding this speed.

The pump must be constructed in such a manner that all wearing parts may be adjusted in a convenient manner without having to remove any parts of the machine.

The **Valves** may be mechanically operated, or poppet but the former are preferred and if poppet valves are used they must be removable by a valve cage, without breaking any pipe connection and the wearing parts must be capable of renewal.

PISTON—must have at least two rings and they must be arranged so that joints will always be at least 90 degrees apart.

The piston must have a very slight clearance approximately 1-16 inch from the heads at end of strokes and the valve pockets must be small as possible to prevent air cushion.

Piston rod shall have a gland of ample size to keep air tight without undue pressure on same.

CROSS HEAD—An approved design of cross head, running in double guides shall be provided and means of adjusting cross head and cross head pin bearing in a convenient manner.

JOURNALS—All journals shall be of ample size to hold the moving parts rigidly in perfect alignment, without undue wear.

LUBRICATION—Shall be provided to properly lubricate every moving part in a thoroughly reliable manner. (If mechanical force feed oiler is desired to lubricate all parts, specify same).

TEMPERATURE RISE—The exhauster should be so designed that the temperature rise of any of the moving parts shall not exceed 100 degrees Fahr. above the surrounding atmosphere when run for at least two hours at full load and must be capable of maintaining these conditions indefinitely at full load if so required.

SUB-BASE—A substantial cast-iron sub-base shall be provided on which the exhauster and motor shall be mounted in perfect and permanent alignment and means shall be provided thereon for taking up slack in the chain drive. If required by architect, holes shall be provided in the sub-base for grouting.

NAME PLATE—The machine shall be provided with a name plate showing the Manufacturers name; number of revolutions per minute; amount of air displaced in cubic feet per minute; also the bore and stroke and the number of horsepower required for its operation.

(NOTE—If a cheaper form of plant is desired, omit specifying the type of pump, but require the full capacity and vacuum and require all bidders to state: Type of pump, dimensions of cylinder and piston (in rotary types), the displacement and guaranteed vacuum with rated number of tools in simultaneous operation having an area of 1 square inch at opening of each.)

MOTOR—Shall be at least................Horsepower (Number of sweeper capacity multiplied by 3) and shall be adapted for use on ....Current of..........volts, ...Cycles, ...Phase. It shall be of standard make and architect reserves privilege of specifying the make. Motor shall be of medium speed and shall be capable of driving the exhauster under full rated load indefinitely without undue heating and shall operate without objectionable sparking.

DRIVE—Between motor and exhauster shall be by means of a **Silent Chain Drive** of Renold, Peerless V, or equal and at least six inches of extra links shall be provided for renewals. Chain drive shall be of ample size and have at least 50 per cent. margin for safety.

(NOTE—In residential and medium size plants a leather belt may be permitted.)

SEPARATOR SYSTEM—(For sizes 1, 2, and 3 sweeper)—Separator must be guaranteed to prevent any particles of dust entering the ma-

chine and must not offer excessive resistence to air passage. Shell must be of cast iron or boiler shell construction and stand on cast iron legs of sufficient height to insure easy removal of dirt. The interior must be easily accessible and bags, if used, arranged to be easily shaken. A spare bag must be furnished.

FOR SIZES LARGER THAN 3 SWEEPER—Separator tanks shall be constructed of cast iron or be of boiler shell construction and shall effectively remove all particles of dust and dirt from the air before it reaches the pump. The separator system shall operate **Without Using Bags or Screens** and shall be of either the spiral, cyclone type, slowing the air current until the dirt drops, or shall be of the wet type washing the air under water effectively, or may consist of both types, or of **Automatic Self Flushing Type,** cleaning entirely by washing the air with water, and automatically dumping into sewer at determined periods without attention. The internal resistance of the separating system must be low. **Note—If it is desired to use the equipment for taking up scrub water** then the **Automatic Type Should be Specified, Self Flushing.**

AUTOMATIC CONTROL—A simple means of vacuum control shall be provided which shall decrease the current consumption in direct proportion as sweepers are shut off and the efficiency of same must be at least 50 per cent. and bidders are required to state the type regulator they propose to furnish.

HOSE—The hose is to be of 1 inch internal diameter (**Flexible Steel**) of flexible steel, capable of being bent into a circle approximately 6 inches in diameter and packed with rubber. Same to be guaranteed air tight and provided with approved standard threaded hose connections.

RUBBER—To be smooth internal bore, wire reinforced, non-collapsible of best grade and provided with standard hose connections.

Hose shall be furnished in following lengths......................

(Specify sufficient to allow each sweeper to reach all points of building. Hose comes in 25 and 50 foot lengths).

HOSE CONNECTIONS— ......(Number)...... hose connections shall be furnished as part of the equipment (The number required being the number of risers multiplied by the number of floors) and these shall be of the cap-and chain type, having gasketed cap and standard hose threads. The fitting shall be nickle (Or brass) highly polished.

(NOTE—If it is necessary to have any of the outlets of the flush type, the number of each should be mentioned, as the flush type will cost a trifle more. If conditions permit, the cap-and-chain type is the most reliable and satisfactory, as well as cheaper.)

CLEANING TOOLS—RENOVATORS—Carpet renovators must have rounded edges that will not cut the carpet nap.

The renovators shall be constructed of aluminum as far as possible for lightness, but, where subject to hard wear, they shall be of brass

and nickeled. All parts to be highly polished and of neat appearance.

Openings through the renovators should be one square inch in area at all points. (For more than one sweeper): Shut-off valves are to be provided for all operating handles and position, (open or shut,) to be indicating. Sets of renovators shall be provided for cleaning carpets, rugs, bare floors of all kinds, walls and ceilings (The latter should be swiveled) and upholstery and drapery. An extension handle at least 60 inches long and coupling should be provided for lengthening out the wall and ceiling tools.

(If special tools are required they should be enumerated and if it is desired to scrub, a number of squeegee brushes should be specified capable of taking up dirty water).

GUARANTEE—The vacuum contractor shall guarantee the purchaser immunity from any annoyance or expense on account of matters pertaining to patent or infringement proceedings and shall also guarantee all parts of the equipment to be perfect in design, material and workmanship and shall replace, free of expense to purchaser, any parts showing defects within one year from date of delivery.

Vacuum contractor shall also guarantee his exhauster to comply with all the requirements herein contained, to have the full capacity called for and operate at the required speed and with the power specified.

INSTALLATION—If it is desired to have the vacuum contractor do the piping and installation work as well, then specifications should so state and include—

PIPING—See preceeding specifications on Piping, which may be included herein.

ELECTRICAL WORK—See preceding specifications on electrical work and entire wiring from main center or merely connecting up from a point 10 feet from the motor can be called for at architect's option.

FOUNDATION—See previous specifications covering this feature.

ASSEMBLING—The contractor shall see that all details and accessories necessary to a complete system, including all valves and appliances are supplied and properly connected and the machine placed in proper running order ready for a demonstration and at such time it shall be turned over to the architect or his representative for test and acceptance.

The pipes and fittings of the vacuum plant should be left presenting a neat appearance and all pipes within twenty feet (Or in the same room if small) should receive a coat of black asphaltum paint (Unless different color is preferred).

All dirt, or refuse on the premises resulting from the work of the vacuum contractor shall be removed and any damage caused by or resulting from his work shall be repaired at his expense and he shall leave the premises in as good condition as at the time he entered them.

APPENDIX

COMPARISON OF DIFFERENT SYSTEMS.

The question of a suitable vacuum plant is usually first divided between a comparison of **high vacuum** versus **low vacuum,** and, in the writer's opinion, the **high vacuum** systems offer greater advantages in every way than the low vacuum.

The first consideration in a plant is to get proper results, and there is no questioning the fact that high vacuum will do more rapid cleaning of tenacious material, and remove material which a low vacuum system cannot handle. It is not practicable to require the operator of the system to remove lint and threads by hand, and the machine should be capable of doing it; therefore, the high vacuum.

Another important matter is the consideration of pipe stoppages Removal of stoppages in pipes is a costly operation, and even though the pipe line may be installed in the most careful manner, it is most probable that stoppages will from time to time occur in the bends of the pipe. With high vacuum, the pipe line is usually **self-cleaning,** owing to the fact that when an obstruction occurs, the effect is similar to closing the pipe line, and the vacuum rises to a high point (as high as 27 inches of mercury in some cases), and will almost invariably pull the obstruction out from the greatly increased vacuum. With low vacuum systems, the vacuum does not rise when an obstruction occurs, and in the fan types actually drops off, owing to the fact that the fan cannot get the air to work on, on which its vacuum depends.

High vacuum systems employ small hose of 1 inch to 1¼ inches internal diameter, which can be made substantial and strong, and still be light and flexible. The low vacuum systems employ hose of 1¾ inches to 2 inches internal diameter, which, if made in a substantial manner, is very cumbersome and heavy, or if made very light is not durable for commercial service. The same applies to the tools and handles. In making light enough for commercial service, strength is sacrificed to make the devices light.

Low vacuum systems are of the multivane or centrifugal fan type, and, as there is a strong tendency toward cavitation when the vacuum of a centrifugal fan reaches one inch of mercury. The efficiency drops off very rapidly above this point.

For high vacuum the positive displacement pumps are required, and, while their mechanical friction is greater, their efficiency is much higher, as they have far less **air friction** and their mechanical efficiency is approximately three times that of any fan type. The comparison is very similar to driving an automobile by an air propellor as against a wheel drive. The air propellor would have practically no mechanical

friction, but its efficiency developed in propelling the car would be far less than a positive drive.

Of the positive displacement pumps, the double acting reciprocating is, of course, the most efficient and most generally understood by mechanics, and is to be preferred where first cost is not the main consideration.

CARE OF HOSE.

The vacuum hose should be handled carefully, to insure long life. It should not be kinked, and when not in use should be coiled in a three-foot diameter roll, or preferably hung on hose racks or reels.

If a hose stops up, it should be turned end for end, and the end at the renovator held against the inlet of the riser. This will pull the obstruction back in the direction from which it lodged, and will in nearly every case cause an immediate clearance of the stoppage.

With high vacuum, the effect may be increased by holding the hand over the open end of the pipe until the vacuum has reached a high point, and then suddenly removing the hand, allowing the impact of the air to strike the stoppage, which will offer a further means of removing the obstruction.

Hose is usually provided with a reinforcement at the ends, to prevent kinking, and it is well to specify a reinforcement, as it will save considerable damage.

If rubber hose is used, care should be taken not to allow tacks or pins to be taken up, as they will puncture the hose and cause stoppages. Metal hose is not affected by sharp objects

If the vacuum system is used to remove scrub water, hose should be cleaned at the close of the work by holding the end of the hose in a bucket of water and passing about two buckets of water through the hose, to clean out all dust, and then allowing the air to draw through the hose for a few minutes to thoroughly dry it. Once a week it is well to pass a little lye-water through the pipes, and immediately follow it with clear water, and dry as before.

Metal hose appears to be the most satisfactory hose where subject to hard usage, and is much more easily handled.

Practical Use of Vacuum Cleaning in Office Buildings.

Some building managers use the vacuum cleaning plant two or three times a week, some every night and each plan has its advocates.

It is the writer's opinion based on careful observation, that the most satisfactory method is to vacuum the rooms every night—in fact, dispense with brooms. The janitor crew should be divided, having a certain portion of the force to "Pick up," cleaning the large particles, papers, boxes and rubbish, (In fact all but the fine particles which the vacuum is to clean), take care of cuspidors, etc., and then arrange for the vacuum men to do nothing but use their apparatus. They become skillful and can accomplish much more than if they are required to stop and attend to several kinds of work and also waste power on the sweepers thereby.

A proficient vacuum man after a couple of weeks work should clean the floor of an average office in five minutes and should average approximately 32,000 square feet in nine hours. The transoms in the corridors should be cleaned twice a week with the wall brush and this will require about 15 minutes to an average floor.

The walls and ceilings should receive a thorough cleaning once every four or six months.

HIGH VACUUM—EFFECT ON RUGS AND CARPETS.

Some are of the opinion that high vacuum (12 inches or more) is injurious to the nap of carpets and rugs. **This is not a fact** and the use of a vacuum of 12 inches every night will actually cause less wear on the rugs than a 6 inch vacuum. The reason is as follows.

Wear on rugs is due to a large extent from sharp edges on the renovators which shears off the nap from purely mechanical means, independent of the vacuum, therefore it should be ascertained in all cases that the edges of renovators are rounding and will not cut the nap.

As a vacuum of 15 inches is equivalent to air pressure of only 7½ pounds per square inch it is ridiculous to think that this could injure a carpet. The high vacuum pulls out dirt with one application of the renovator, whereas low vacuum usually requires a frequent rubbing back-and-forth movement to loosen the dirt before the low vacuum can pull it out—this rubbing causes much more wear than the high vacuum which will pull it straight out by passing over the nap but once. This is particularly the case where mud has become caked in a carpet—the low vacuum plant is obliged to break the mud particles up by repeatedly running over it and in so doing the nap is apt to crack off with the mud, however, the high vacuum pulls the mud straight off the ends of the fibers and does not crack them.

Another point where high vacuum is a saver of rugs is the fact that it gets the grit out from the body of the carpet—whereas a low vacuum cannot draw it, and it is the grit in a carpet continually walked over that eventually grinds the carpet to pieces. Without grit, carpets and rugs will wear almost indefinitely.

PORTABLE VS. STATIONARY VACUUM PLANTS.

The sphere of usefulness of the portable vacuum plant lies entirely in residence work. It has no place whatsoever in commercial cleaning.

In an office or public building the cleaning of the building is a commercial proposition—it is done on a wholesale scale and it should therefore be reduced to the lowest cost. The question is—What is the most expensive item in cleaning a building? The answer is **Time.** Therefore the question to be solved is **How to Save Time.** Compare six janitors using 6 portable machines of say ⅛ horsepower each, (If they are of the ordinary type), as against 6 janitors each with 3 horsepower at his disposal and nothing to move but his hose. The

stationary plant will clean in one tenth the time and do five times better work at the increased speed. The current consumption to cover a given area may be about equal but the high powered plant will cut the labor item into a small fraction. Furthermore a stationary plant is cheaper than a portable, besides being far more efficient, for, if the same power in portables were provided, their cost would run several times more than the same power in a stationary plant. The reason portables **appear** cheaper, is because of their diminutive power. A stationary plant of small power and lower cost could be installed which would in reality do far better work, but from the standard of a stationary plant would be too small to consider. The portable is a plaything when considered for office buildings and any one considering the matter seriously cannot fail to realize it. Some portable plants are of larger size, running as high as 2 and 3 horsepower. Of these large plants there is naturally no fault to find in effectiveness, providing they approach 3 horsepower to each machine, but they then become very unwieldy and have to be carried from floor to floor on elevators, wasting valuable time in transporting the machine around which should be devoted to sweeping. Further, time is lost in connecting and disconnecting to the electric supply.

Another feature against the portable is the unsanitary feature of drawing the air from the under surface of the carpet where the dust has settled, and discharging this dust laden air back into the room where the machine is operating. This dust in the carpet is an impalpable powder and will pass through the mesh of an ordinary canvas sack such as is used on portable separating tanks. A dampened cloth held in front of the discharge of a portable machine will soon be discolored from the dirt in the exhaust air.

REMOTE CONTROL SYSTEMS.

It is sometimes desirable to arrange a residential system so that it may be started and stopped from any floor in the house and for this class of service a remote control switch is necessary.

A circuit of three wires should be run from the location of the plant to each of the control points. At each control point a flush (or exposed type) switch is installed, for direct current a **momentary contact** switch and for alternating current a 4-way switch. These switches when operated actuate a remote control switch in the vicinity of the vacuum plant, which in turn connects the power to the motor, thereby replacing the hand starting switch usually used. If direct or polyphase current is used, the remote control switch automatically delivers the current to the motor in proper stages to insure its starting gradually. If single phase the motor is usually thrown straight accross the line.

A most satisfactory line of automatic starting devices is manufactured by the **Sundh Electric Co.**, of New York.

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